For reference only.

ANSWER SHEET
Diagnostic Test

Determine the correct answer for each question. Then, using a No. 2 pencil, blacken completely the oval containing the letter of your choice.

1. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
3. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
4. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
5. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
6. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
7. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
8. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
9. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
10. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
11. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
12. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
13. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
14. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
15. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
16. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
17. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

18. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
19. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
20. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
21. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
22. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
23. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
24. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
25. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

ON THE ACTUAL CHEMISTRY TEST, THE FOLLOWING TYPE OF QUESTION MUST BE ANSWERED ON A SPECIAL SECTION (LABELED "CHEMISTRY") AT THE LOWER LEFT-HAND CORNER OF PAGE 2 OF YOUR ANSWER SHEET. THESE QUESTIONS WILL BE NUMBERED BEGINNING WITH 101 AND MUST BE ANSWERED ACCORDING TO THE DIRECTIONS.

CHEMISTRY* Fill in oval CE only if II is a correct explanation of I.

	I	II	CE*
101.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
102.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
103.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
104.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
105.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
106.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
107.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
108.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
109.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
110.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
111.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
112.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
113.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
114.	Ⓣ Ⓕ	Ⓣ Ⓕ	◯

ON THE ACTUAL CHEMISTRY TEST, THE REMAINING QUESTIONS MUST BE ANSWERED BY RETURNING TO THE SECTION OF YOUR ANSWER SHEET YOU STARTED FOR CHEMISTRY.

26. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	42. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	57. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
27. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	43. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	58. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
28. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	44. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	59. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
29. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	45. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	60. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
30. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	46. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	61. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
31. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	47. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	62. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
32. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	48. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	63. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
33. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	49. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	64. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
34. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	50. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	65. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
35. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	51. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	66. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
36. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	52. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	67. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
37. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	53. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	68. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
38. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	54. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	69. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
39. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	55. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	70. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
40. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	56. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	71. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
41. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ		

THE DIAGNOSTIC TEST

Note: For all questions involving solutions, you should assume that the solvent is water unless otherwise noted. **Reminder: You may not use a calculator on this test!**

The following symbols have the meanings listed unless otherwise noted.

H	=	enthalpy
M	=	molar
n	=	number of moles
P	=	pressure
R	=	molar gas constant
S	=	entropy
T	=	temperature
V	=	volume
atm	=	atmosphere
g	=	gram(s)
J	=	joules(s)
kJ	=	kilojoules
L	=	liter(s)
mL	=	milliliter(s)
mol	=	mole(s)
mm	=	millimeter(s)
V	=	volt(s)

PART A

Directions: Every set of the given lettered choices below refers to the numbered statements or formulas that immediately follow it. Choose the one lettered choice that best fits each statement or formula; then fill in the corresponding oval on the answer sheet. Each choice may be used once, more than once, or not at all in each set.

Questions 1–4 refer to the following elements:

(A) Fluorine

(B) Chlorine
(C) Bromine
(D) Iodine
(E) Astatine

1. The element that is most active chemically

2. The element with the smallest ionic radius

3. The element with the lowest first ionization energy

4. The element that, at room temperature and pressure, exists as a bluish-black solid

Questions 5–7 refer to the following sublevels:
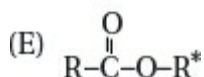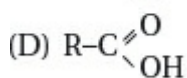
(A) $1s$
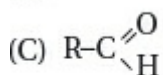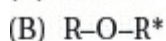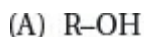(B) $2s$
(C) $3s$
(D) $3p$
(E) $3d$

5. Contains up to 10 electrons.

6. Contains one pair of electrons in the ground-state electron configuration of the lithium atom.

7. Is exactly one-half filled in the ground-state electron configuration of the phosphorus atom.

Questions 8–12 refer to the following:

(A) Avogadro's number
(B) Boyle's Law
(C) Charles's Law
(D) Dalton's Theory
(E) Gay-Lussac's Law

8. Proposes basic postulates concerning elements and atoms

9. Proposes a relationship between the combining volumes of gases with respect to the reactants and gaseous products

10. Proposes a temperature-volume relationship of gases

11. Proposes a concept regarding the number of particles in a mole

12. Proposes a volume-pressure relationship of gases

Questions 13–16 refer to the following structures:

(A) R–OH

(B) R–O–R*

(C) $R-C\overset{\nearrow O}{\underset{\searrow H}{}}$

(D) $R-C\overset{\nearrow O}{\underset{\searrow OH}{}}$

(E) $R-\overset{O}{\underset{\|}{C}}-O-R*$

(*Alkyl group that is not necessarily the same as R)

13. The organic structure that includes the functional group of an aldehyde

14. The organic structure that includes the functional group of an acid

15. The organic structure that includes the functional group of an ester

16. The organic structure that includes the functional group of an ether

Questions 17–21 refer to the following:

(A) $H_2(g)$

(B) $CO_2(g)$

(C) $2N_2O(g)$

(D) $2NaCl\ (aq)$

(E) $H_2SO_4(dilute\ aq)$
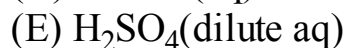
17. The expression that can be used to designate a linear nonpolar molecule that contains polar bonds

18. The expression that can be used to designate 2 moles of atoms

19. The expression that can be used to designate 3 moles of atoms

20. The expression that can be used to designate a maximum of 3 moles of ions

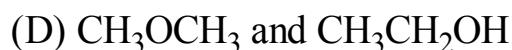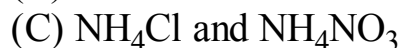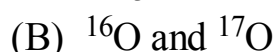21. The expression that can be used to designate 6 moles of atoms

Questions 22–25 refer to the following pairs of substances:

(A) NH_3 and N_2H_4

(B) ^{16}O and ^{17}O

(C) NH_4Cl and NH_4NO_3

(D) CH_3OCH_3 and CH_3CH_2OH

(E) O_2 and O_3
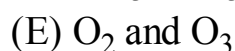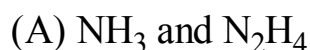
22. Are isotopes

23. Have both ionic and covalent bonds

24. Are allotropes

25. Are strong electrolytes in aqueous solutions

PART B

ON THE ACTUAL SAT SUBJECT TEST IN CHEMISTRY, THE FOLLOWING TYPE OF QUESTION MUST BE ANSWERED ON A SPECIAL SECTION (LABELED "CHEMISTRY") AT THE LOWER LEFT-HAND CORNER OF PAGE 2 OF YOUR ANSWER SHEET. THESE QUESTIONS ARE NUMBERED BEGINNING WITH 101 AND MUST BE ANSWERED ACCORDING TO THE FOLLOWING DIRECTIONS.

Directions: Every question below contains two statements, I in the left-hand column and II in the right-hand column. For each question, decide if statement I is true or false <u>and</u> whether statement II is true or false, and fill in the corresponding T or F ovals on your answer sheet. *<u>Fill in oval CE only if statement II is a correct explanation of statement I.</u>

Sample Answer Grid:

CHEMISTRY *Fill in oval CE only if II is a correct explanation of I.

	I	II	CE*
101.	T F	T F	◯

I   **II**

101. A catalyst can accelerate a chemical reaction   BECAUSE a catalyst can decrease the activation energy required for the reaction to occur.

102. Molten sodium chloride is a good electrical conductor   BECAUSE sodium chloride in the molten state allows ions to move freely.

103. Ice is less dense than liquid water   BECAUSE water molecules are nonpolar.

104. Two isotopes of the same element have the same mass number   BECAUSE isotopes have the same number of protons.

105. A 1.0 g sample of calcium citrate, $Ca_3(C_6H_5O_7)_2$ (molar mass 498 g/mol), contains more Ca than a 1.0 g sample of calcium carbonate, $CaCO_3$ (molar mass 100 g/mol)   BECAUSE there are more Ca atoms in 1.0 mol of calcium carbonate than in 1.0 mol of calcium citrate.

106. About two liters of CO_2 can be produced by 1 gram of carbon burning completely   BECAUSE the amount of gas evolved in a chemical reaction can be determined by using the mole relationship of the coefficients in the balanced equation.

107. A reaction is at equilibrium when it reaches completion   BECAUSE the concentrations of the reactants in a state of equilibrium equal the concentrations of the products.

108. The oxidation number of Mn in MnO_4^-, permanganate, is 8+   BECAUSE the oxidation number of oxygen in most substances is −2.

109. A solution with pH = 5 has a higher concentration of hydronium ions than a solution with a pH = 3   BECAUSE pH is defined as −log $[H_3O^+]$.

110. An endothermic reaction can be spontaneous   BECAUSE both the enthalpy and the entropy changes affect the Gibbs free-energy change of the reaction.

111. Weak acids have small values for the equilibrium constant, K_a,   BECAUSE the concentration of the hydronium ion is in the numerator of the K_a expression.

112. One mole of NaCl contains 2 moles of ions   BECAUSE NaCl is a stable salt at room temperature.

113. A p orbital has a shape that can be described as two lobes along the x, y, or z axis in 3-D space   BECAUSE each of the two lobes of a single p orbital can hold two electrons of opposite spin.

114. H_2S and H_2O have a significant difference in their boiling points   BECAUSE hydrogen sulfide has a higher degree of hydrogen bonding than water.

PART C

Directions: Every question or incomplete statement below is followed by five suggested answers or completions. Choose the one that is best and then fill in the corresponding oval on the answer sheet.

26. Two miscible liquids, when shaken together, will form

       (A) a solution
       (B) a tincture
       (C) a suspension
       (D) a hydrated solution
       (E) a colloid
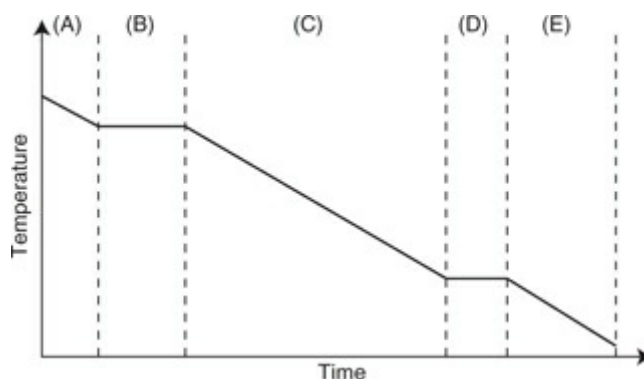
27. A thermometer is used to record the cooling of a confined pure substance over a period of time. During which interval on the cooling graph above is the system undergoing a change of state from a liquid to a solid?

28. If a principal energy level of an atom in the ground state contains 18 electrons, they will be arranged in orbitals according to the pattern

       (A) $s^6p^6d^6$
       (B) $s^2p^6d^{10}$
       (C) $s^2d^6f^{10}$
       (D) $s^2p^6f^{10}$
       (E) $s^2p^2f^{14}$

29. Which of the following molecules is a saturated hydrocarbon?

       (A) C_3H_8
       (B) C_2H_4
       (C) C_4H_6
       (D) CH_3OH
       (E) CH_3COOH

30. A liter of hydrogen is at 5.0°C temperature and under 640. torr pressure. If the temperature were raised to 60.0°C and the pressure decreased to 320. torr, how would the liter volume be modified?

(A) $1\,L \times \dfrac{5.0}{60.} \times \dfrac{640.}{32.}$

(B) $1\,L \times \dfrac{60.}{5.0} \times \dfrac{320.}{640.}$

(C) $1\,L \times \dfrac{278.}{333.} \times \dfrac{640.}{320.}$

(D) $1\,L \times \dfrac{333.}{278.} \times \dfrac{640.}{320.}$

(E) $1\,L \times \dfrac{333.}{278.} \times \dfrac{320.}{640.}$

31. Of the following statements about the number of subatomic particles in an ion of $_{16}^{32}S^{2-}$, which is (are) true?

       I. 16 protons
     II. 14 neutrons
    III. 18 electrons

    (A) II only
    (B) III only
    (C) I and II only
    (D) I and III only
    (E) I, II, and III

32. The most reactive metallic elements are found in
    (A) the upper right corner of the periodic chart
    (B) the lower right corner of the periodic chart
    (C) the upper left corner of the periodic chart
    (D) the lower left corner of the periodic chart
    (E) the middle of the periodic chart, just beyond the transition elements

33. If 1 mole of each of the following substances was dissolved in 1,000 grams of water, which solution would have the highest boiling point?
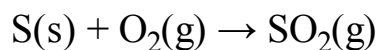   (A) NaCl
    (B) KCl
    (C) $CaCl_2$
    (D) $C_6H_{10}O_5$
    (E) $C_{12}H_{22}O_{11}$

34. A tetrahedral molecule, XY_4, would be formed if X were using the orbital hybridization
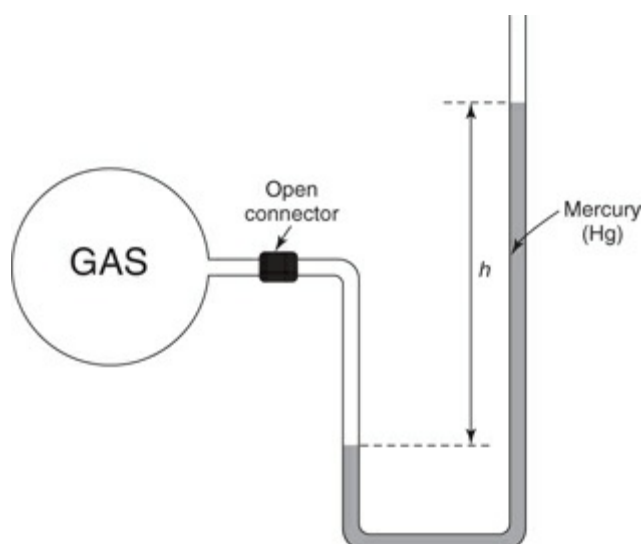   (A) p^2
    (B) s^2
    (C) sp

(D) sp^2

(E) sp^3

35. In the following reaction, how many liters of SO_2 at STP will result from the complete burning of pure sulfur in 8 liters of oxygen?

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

(A) 1
(B) 4
(C) 8
(D) 16
(E) 32

36. In the above laboratory setup to measure the pressure of the confined gas, what will be true concerning the calculated pressure on the gas?

(A) The gas pressure will be the same as the atmospheric pressure.
(B) The gas pressure will be less than the atmospheric pressure.
(C) The gas pressure will be greater than the atmospheric pressure.
(D) The difference in the height (h) of mercury levels is equal to the pressure of the gas.
(E) The height (h) of mercury has no effect on the pressure calculation since the column of mercury is only used to enclose the gas volume.

37. Which of the following changes in the experiment shown in question 36 would cause the pressure in the glass container to vary from that shown?

(A) Use a U-tube of a greater diameter and maintain the height of mercury.
(B) Increase the temperature of gas in the tube.
(C) Increase the length of the upper portion of the right side of tubing.

(D) Use a U-tube of a smaller diameter and maintain the height of mercury.

(E) Replace the flask with one that has the same volume but has a flat bottom.

38. Which of the following can be classified as amphoteric?

(A) Na_3PO_4

(B) HCl

(C) NaOH

(D) HSO_4^-

(E) $C_2O_4^{2-}$

39. Standard conditions (STP) are

(A) 0°C and 2 atm

(B) 32°F and 76 torr

(C) 273 K and 760 mm Hg

(D) 4°C and 7.6 cm Hg

(E) 0 K and 760 mm Hg

40. Laboratory results showed the composition of a compound to be 75% carbon and 25% hydrogen. What is the empirical formula of the compound?

(A) CH_4

(B) C_2H_{10}

(C) C_2H_5

(B) CH

(E) C_4H

41. What is the percentage composition of sulfur in sulfur dioxide, SO_2?

(A) 43%

(B) 50%

(C) 54%

(D) 69%

(E) 74%

42. How many moles of hydrogen gas can be produced from the following reaction if 65 grams of zinc and 36.5 grams of HCl are present in the reaction?
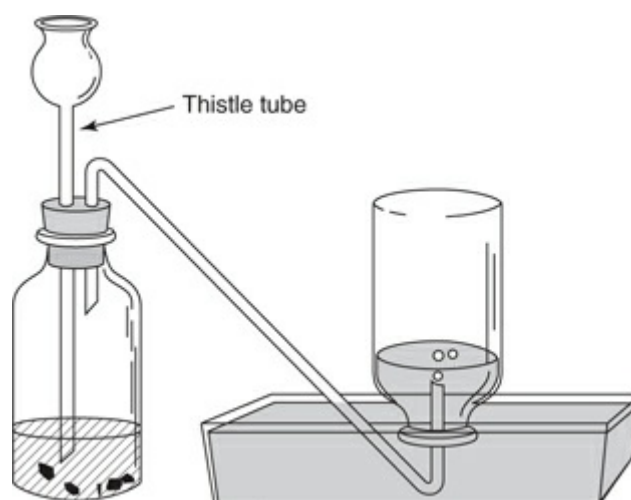
$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$
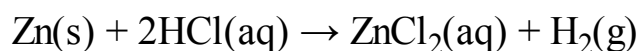
(A) 0.50

(B) 1.0

(C) 3.6

(D) 7.0
(E) 58

**Questions 43 and 44 refer to the following setup.**

43. The following statements were recorded while preparing carbon dioxide gas in the laboratory, as shown above. Which one involves an interpretation of the data rather than an observation?

(A) No liquid was transfered from the reaction bottle to the beaker.
(B) The quantity of solid minerals decreased.
(C) The cloudiness in the bottle of limewater on the right was caused by the product of the reaction of the colorless gas and the limewater.
(D) The bubbles of gas rising from the mineral remained colorless throughout the experiment.
(E) There was a 4°C rise in temperature in the reaction vessel during the experiment.

44. The previous laboratory setup can be used to prepare which of the following?

I. $CO_2(g)$
II. $H_2(g)$
III. $O_2(g)$

(A) I only
(B) III only
(C) I and III only
(D) II and III only
(E) I, II, and III

$$_1^2H + _1^3H \rightarrow _0^1n + \underline{\qquad}$$
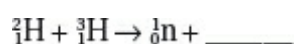
45. The missing product in the nuclear reaction represented above is

(A) ^1_1H
(B) ^3_2He
(C) ^4_2He
(D) ^4_3Li
(E) ^5_3Li

46. Which of the following is (are) true regarding the aqueous dissociation of HCN, $K_a = 4.9 \times 10^{-10}$, at 25°C?

    I. At equilibrium, $[H^+] = [CN^-]$.
  II. At equilibrium, $[H^+] > [CN^-]$.
 III. HCN (aq) is a strong acid.

(A) I only
(B) II only
(C) I and II only
(D) I and III only
(E) I, II, and III

47. This question pertains to the reaction represented by the following equation:

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) + 150 \text{ kJ}$$
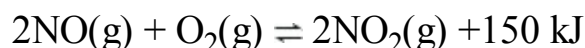
Suppose that 0.8 mole of NO is converted to NO_2 in the above reaction. What amount of heat will be evolved?

(A) 30 kJ
(B) 60 kJ
(C) 80 kJ
(D) 130 kJ
(E) 150 kJ

48. How does a Brønsted-Lowry acid differ from its conjugate base?
(A) The acid has one more proton.
(B) The acid has one less proton.
(C) The acid has one more electron.
(D) The acid has one less electron.
(E) The acid has more than one additional proton.

49. Two containers having 1 mole of hydrogen gas and 1 mole of oxygen gas, respectively, are opened. What will be the ratio of the rate of effusion of the hydrogen to that of the oxygen?